Forecast Informed Reservoir Operations: Bringing Science and Decision-Makers Together to Explore Use of Hydrometeorological Forecasts to Support Future Reservoir Operations

F. Martin Ralph (Presenter)
Center for Western Weather and Water Extremes
UC San Diego/Scripps Institution of Oceanography

Jay Jasperse
Sonoma County Water Agency

Acknowledgments to the FIRO Steering Committee
US Army Corps of Engineers/ERDC and CA DWR AR Programs

Bay Delta Stewardship Council, Sacramento, CA
24 May 2018

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Russian River Reservoirs are Dual Purpose

Flood protection in a flood-prone watershed
(US Army Corp of Engineers)

Water supply for 600,000 people and agriculture
(Sonoma County Water Agency)

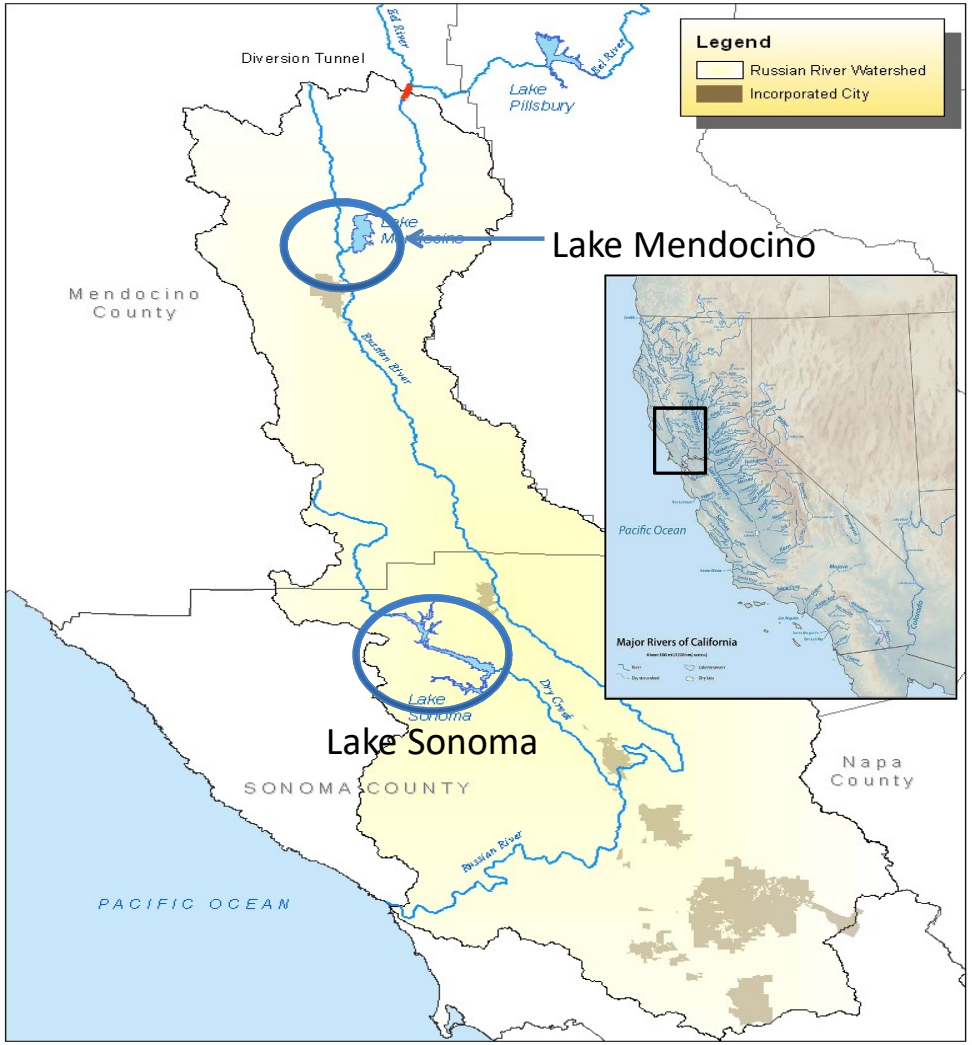
Operations Dictated by
Storage Levels Relative to "Rule Curve"

Lake Mendocino (Coyote Valley Dam)

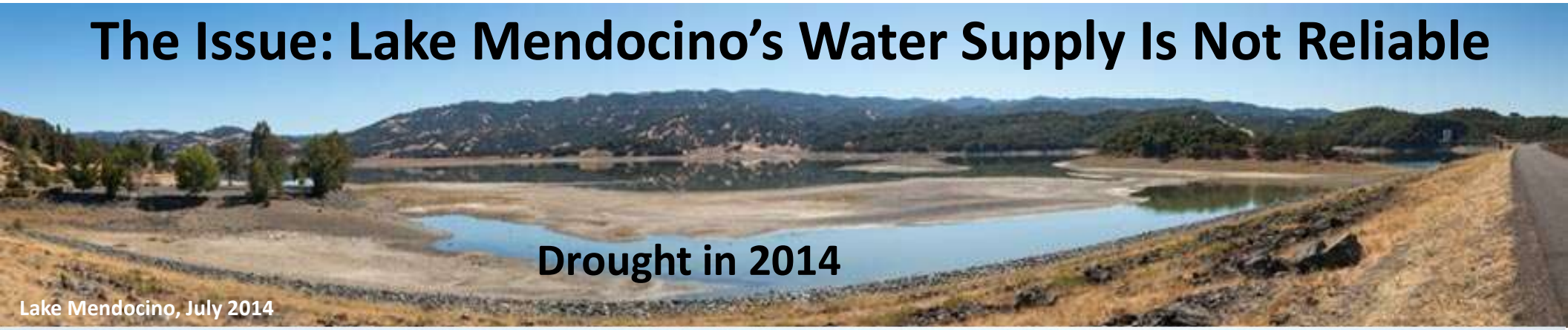
Flood Control Pool (empty space): 48,100 AF
Water Supply Pool: 68,400 A

Lake Sonoma (Warm Springs Dam)

Flood Control Pool:136,000 AF
Water Supply Pool: 245,000 AFF (Nov. 1 – March 1)



The Issue: Lake Mendocino's Water Supply Is Not Reliable



Drought in 2014

Lake Mendocino, July 2014

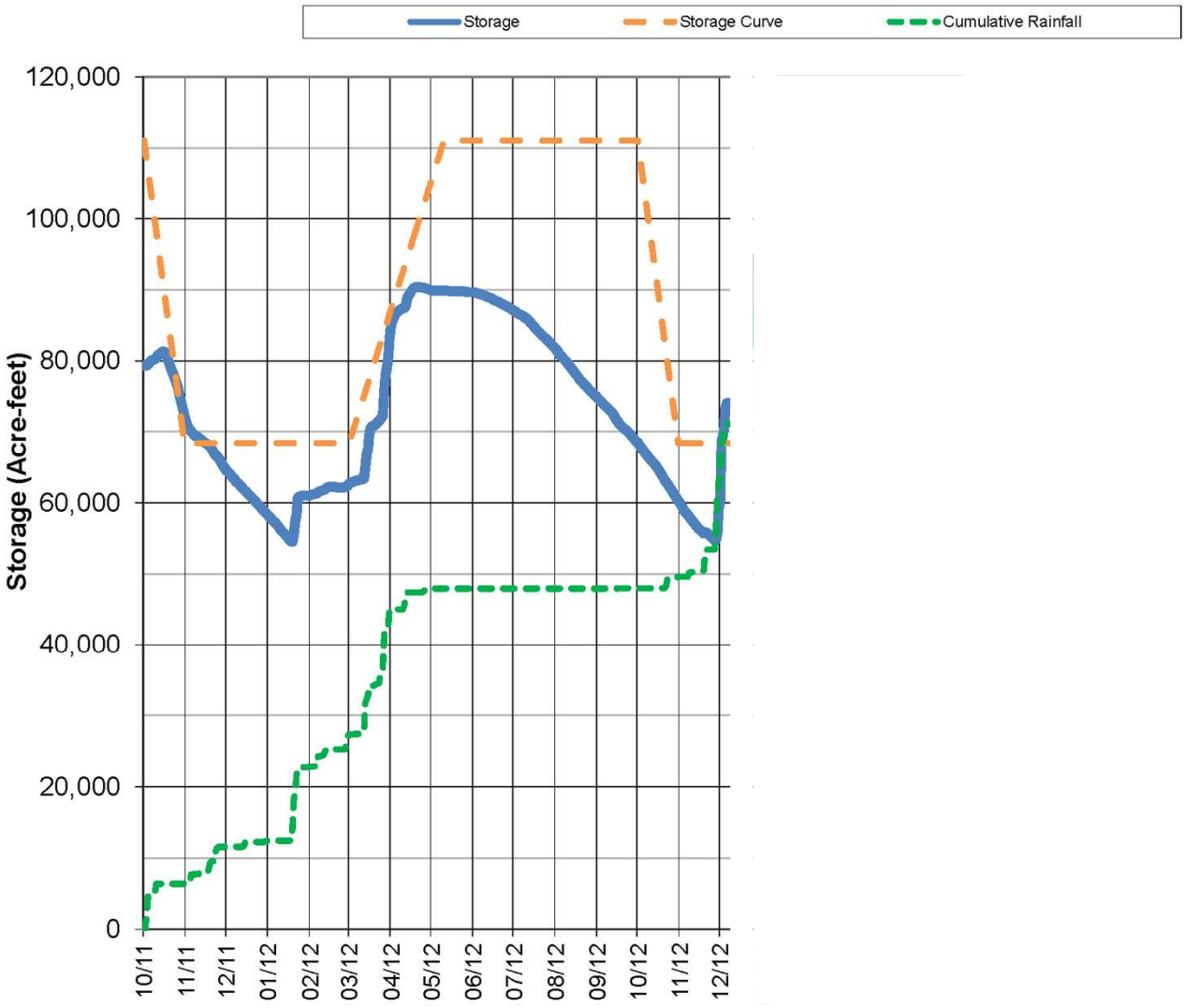
Some Reasons For Low Water Supply Reliability:

- Relatively small storage capacity
- Relatively unproductive watershed
- Reduced inflow from Potter Valley Project (Eel River)
- Highly variable precipitation patterns
  - Almost 50% rainfall from atmospheric rivers
- Future growth & climate change will likely further reduce reliability

Flood in 2014

Russian River near Monte Rio, 9 Feb 2014 *(M. Ralph)*

Lake Mendocino Water Years 2012 - 2014



Lake Mendocino FIRO Steering Committee

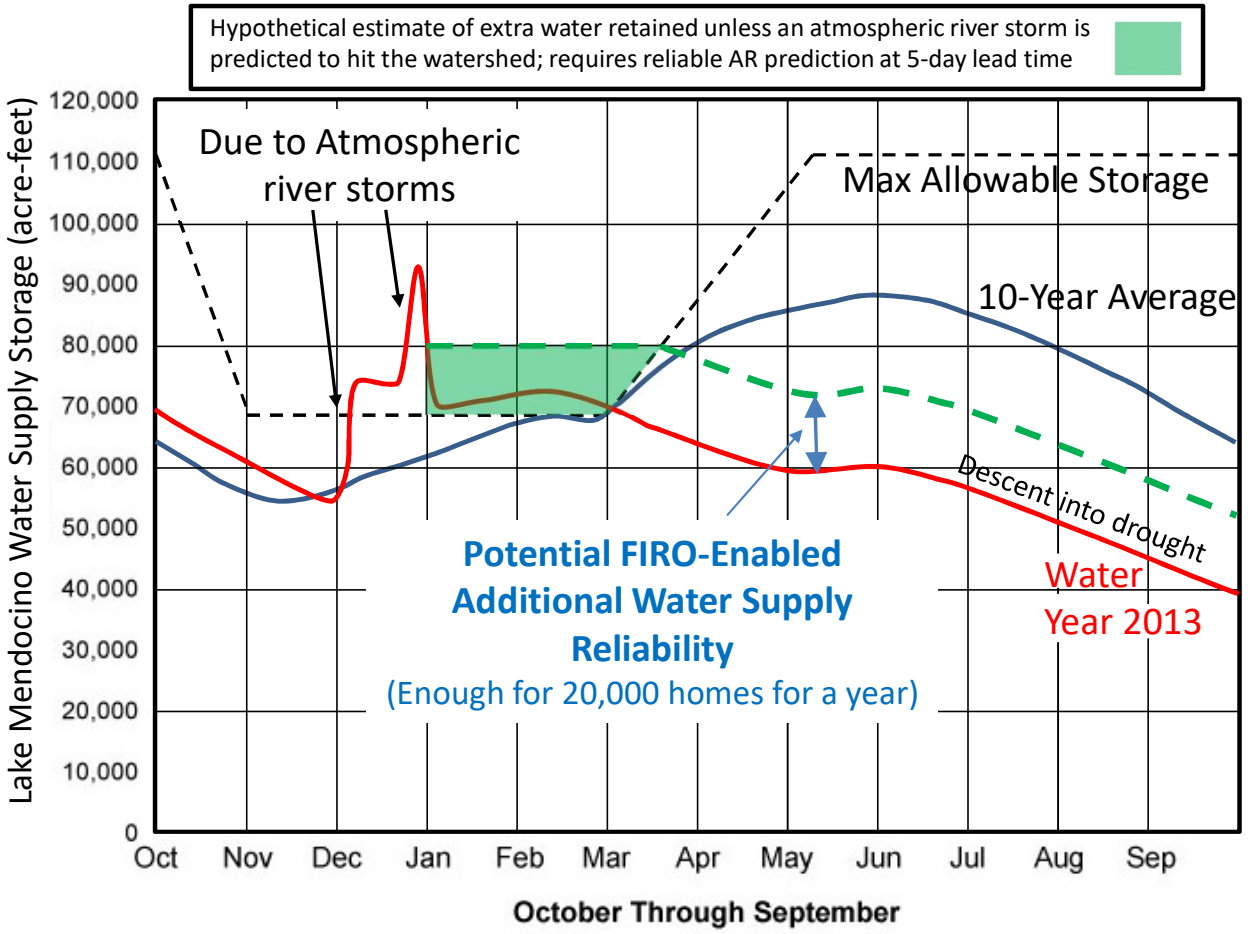
- **Co-Chairs**
  Jay Jasperse – Sonoma County Water Agency
  F. Martin Ralph – UCSD / SIO / CW3E
- **Members**
  Michael Anderson – California DWR
  Levi Brekke – USBR
  Mike Dillabough – USACE / SPN
  Michael Dettinger – USGS
  Joe Forbis – USACE / SPK
  Alan Haynes – NOAA / NWS
  Patrick Rutten – NOAA / NMFS
  Cary Talbot – USACE / ERDC
  Robert Webb – NOAA / OAR

Project Partners

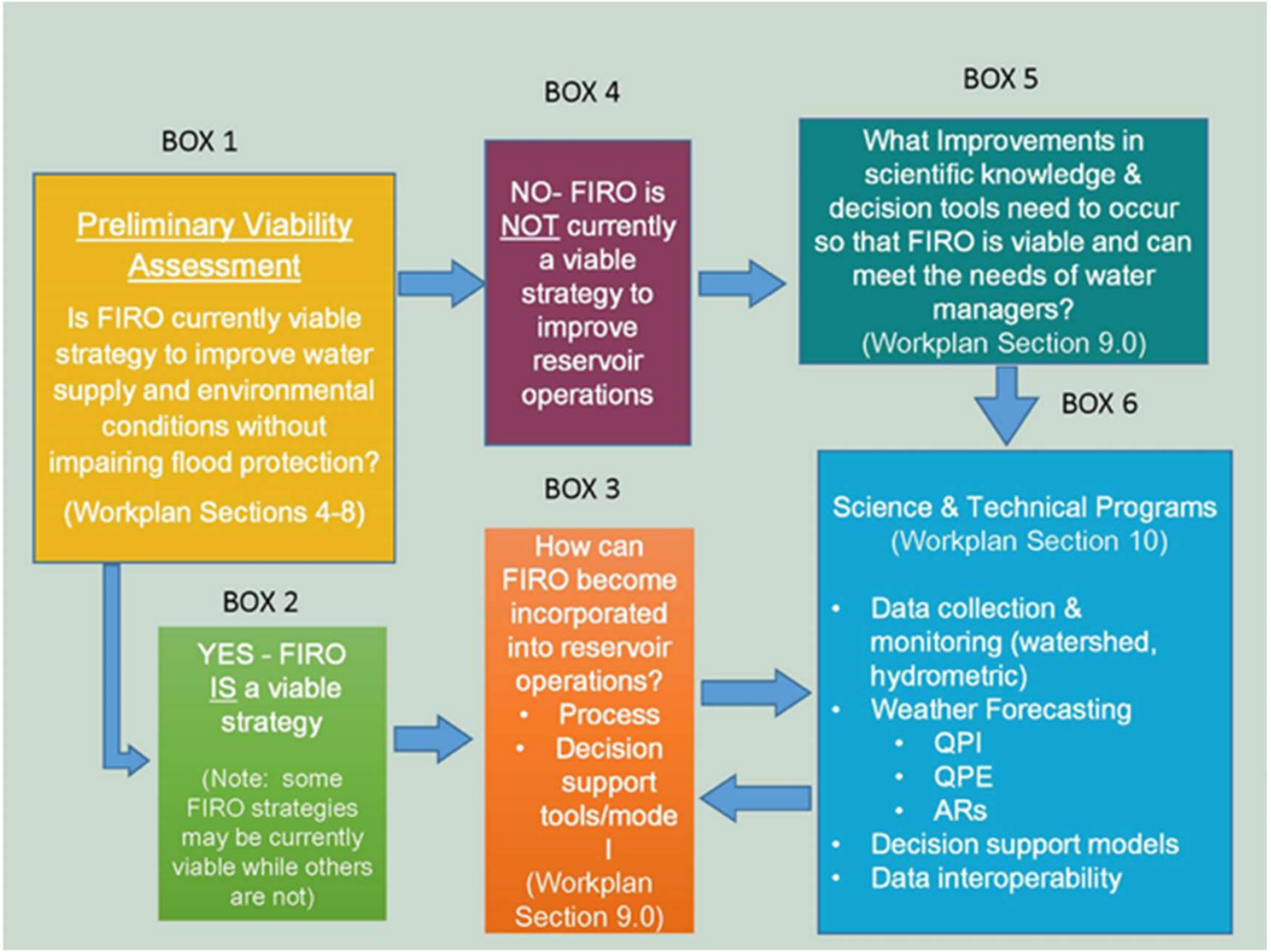
A Comprehensive **Work Plan** to Evaluate FIRO for Lake Mendocino

- Viability Assessment Process
- Evaluation Framework
- Benefits Assessment
- Implementation Strategies
- Technical and Scientific Support

Lake Mendocino Forecast-Informed Reservoir Operations Concept

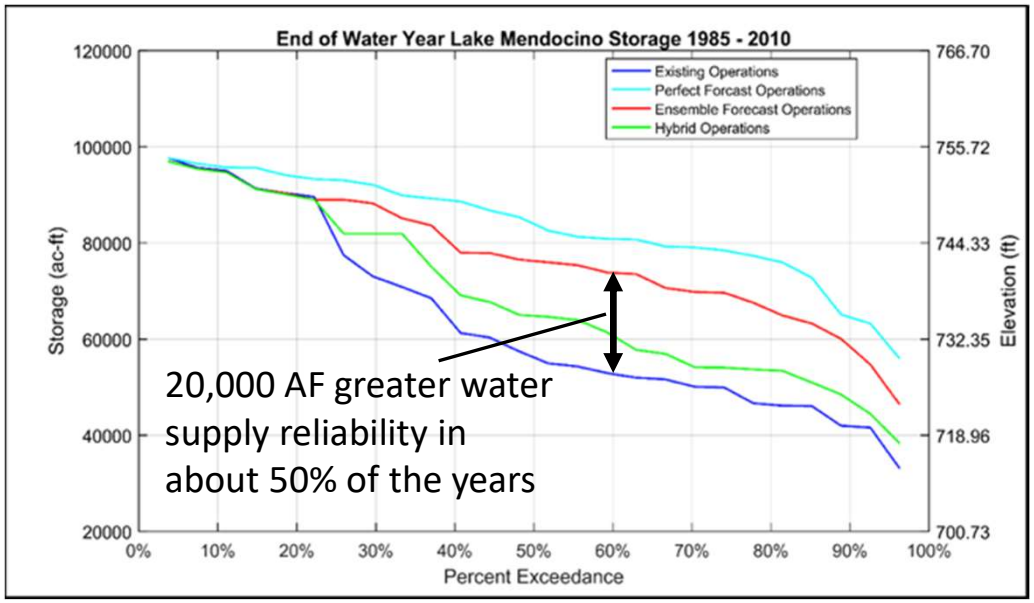


FIRO Viability Assessment Process



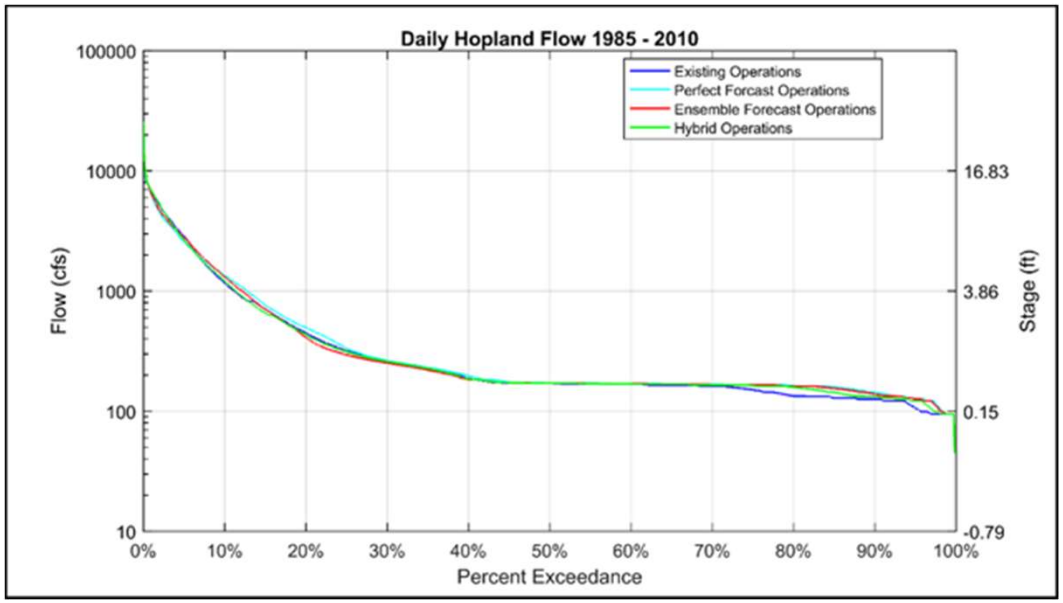
Hypothetical Impacts of FIRO on Water Supply and Flood Risk

Water Supply



✓Substantial gains in water storage over existing operations by leveraging information in streamflow forecasts

Flood Risk



✓Downstream flood control benefits are not impacted

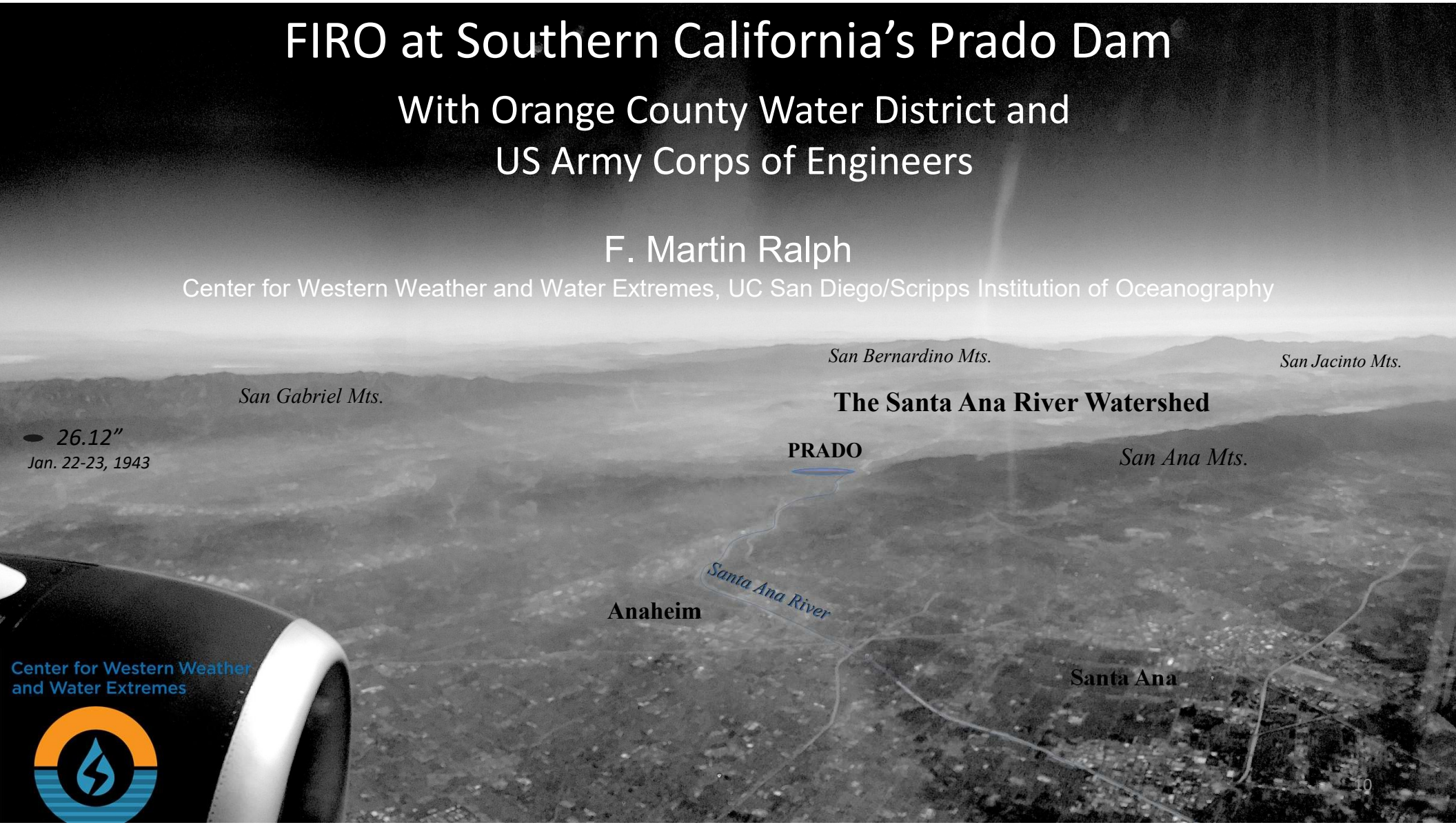
Selected results of FIRO-motivated science

- Established forecast skill requirements, e.g., 3-5 day lead time on heavy precipitation and runoff forecasts
- ARs are the main weather phenomenon that causes extremes
- AR landfall forecasts have useful skill out to a few days
- Mesoscale frontal waves are key source of forecast busts
- AR Recon offers potential to improve AR landfall prediction
- Prediction of no AR landfall has skill beyond 1 week
- Probabilistic streamflow predictions are key; developing thresholds based on ensemble methods
- Exploring roles of distributed, physics-based steamflow models

FIRO at Southern California's Prado Dam

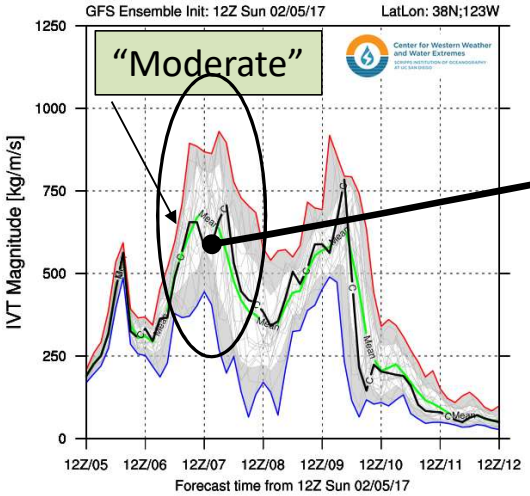
With Orange County Water District and US Army Corps of Engineers

F. Martin Ralph
Center for Western Weather and Water Extremes, UC San Diego/Scripps Institution of Oceanography

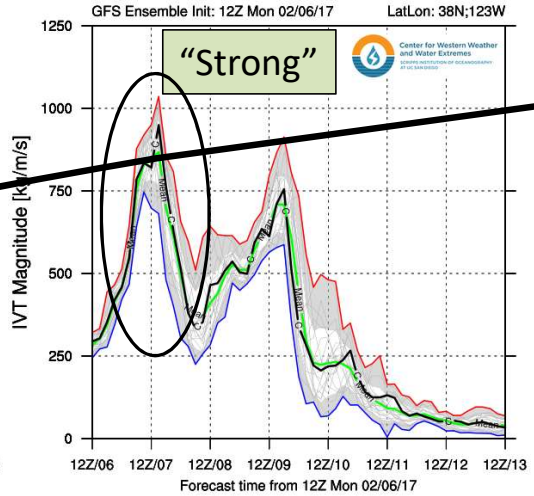


NCEP GEFS dProg/dt Example from February 2017 – "Oroville Case" (dam spillway issue)

Oroville Dam Spillway Damaged



Init: 12Z/5 Feb



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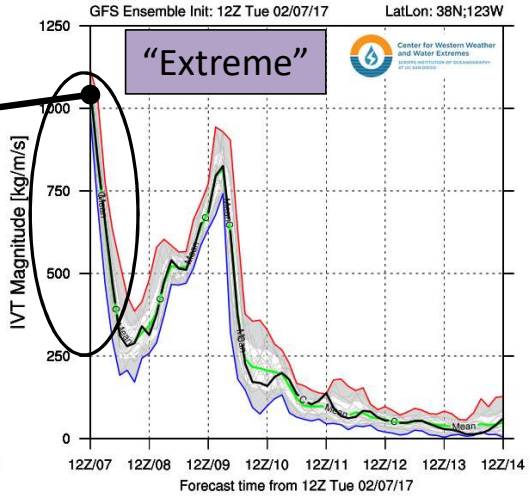

Init: 12Z/7 Feb

Image Description: 7-day forecasts of the NCEP GEFS IVT [kg m^{-1} s^{-1}] at 38N, 123W. The following is indicated at each forecast time: ensemble member maximum (red), ensemble member minimum (blue), ensemble mean (green), ensemble control (black), ensemble standard deviation (white shading), and each individual member (thin gray). Time advances from left to right.

Key: Variability in north-south shift of ARs result in increases or decreases in IVT magnitude at the coast. In this case the ARs ultimately ended up **stronger.**

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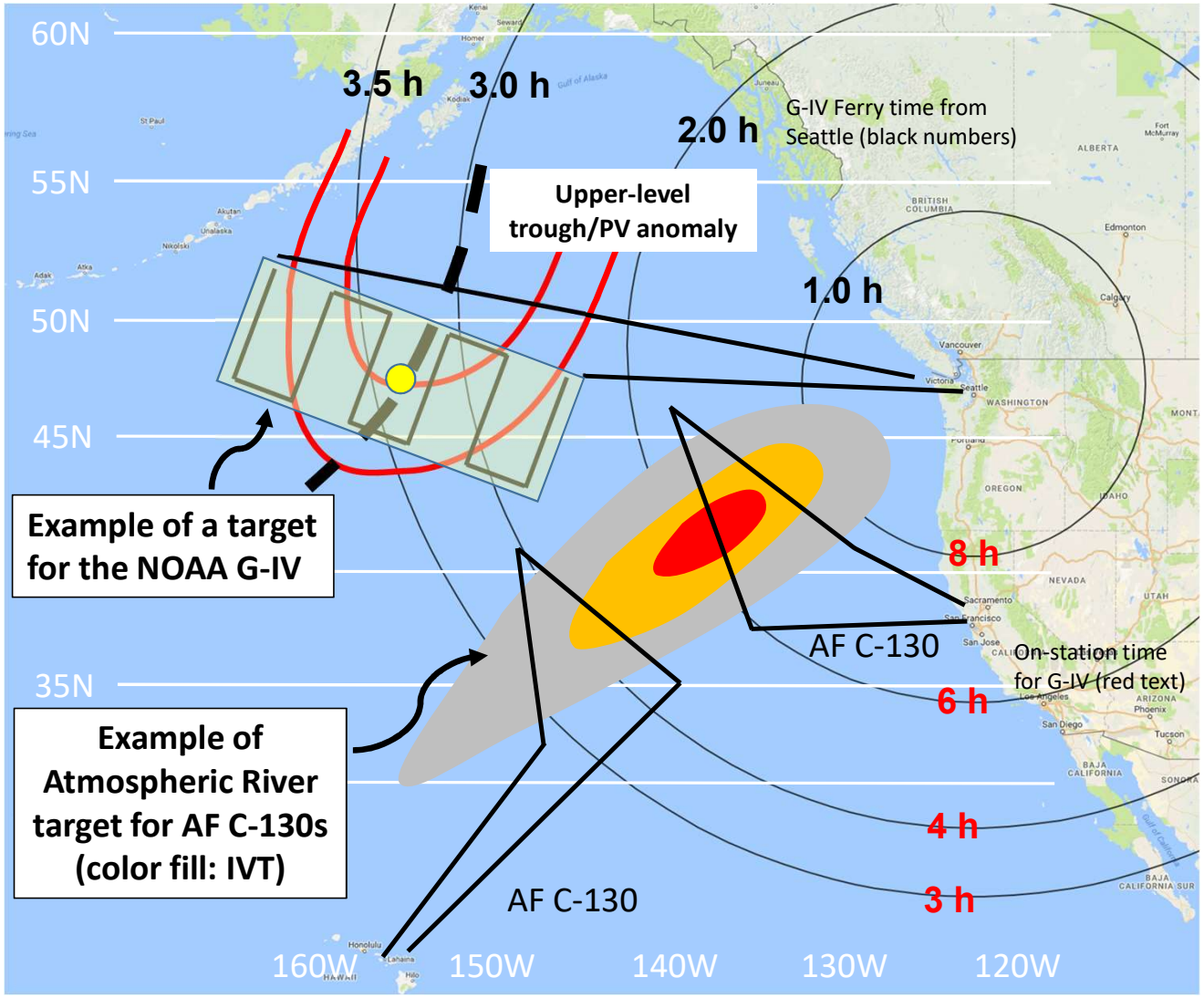
F. M. Ralph (mralph@ucsd.edu) and J. Cordeira

2018
Atmospheric River Reconnaissance Flight Strategies



Center time: 0000 UTC
Dropsonde deployment window:
2100 – 0300 UTC

Each aircraft has a range of about 3500 nm

F.M. Ralph (AR Recon PI) and AR Recon Team

For more information

cw3e.ucsd.edu/FIRO/

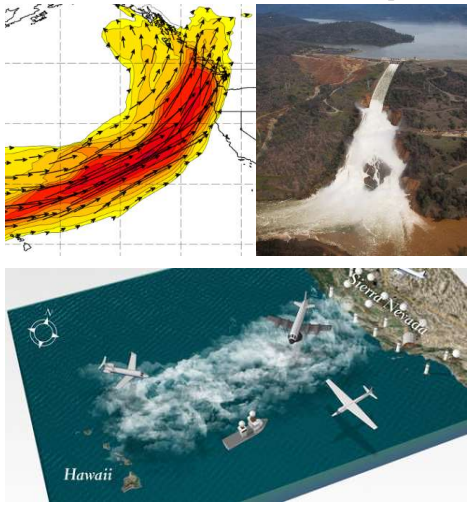
2018 2nd International Atmospheric Rivers Conference

Scripps Institution of Oceanography
La Jolla, California
25-28 June

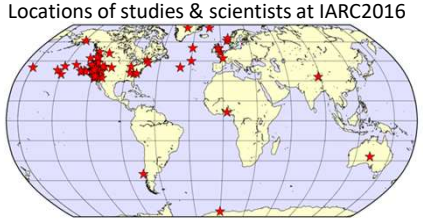
Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

http://cw3e.ucsd.edu/IARC2018

Regions around the globe face challenges in water management due to droughts and/or floods. Atmospheric rivers (ARs) have emerged as a conceptual model to focus hydrologists and atmospheric scientists on the transport mechanisms and impacts of precipitation extremes caused by AR landfall. The frequency, orientation, and strength of ARs determine the occurrence and impact of natural hazards as well as water resource and ecosystem benefits. This conference will bring together experts across the fields of atmospheric, hydrologic, oceanic and polar sciences, water management, civil engineering, and ecology to advance the state of the science and explore needs for new information. Traditional oral and poster sessions will be combined with panel discussions.



Locations of studies & scientists at IARC2016



Banner image by Joshua Stevens, from NASA Earth Observatory using VIIRS data. Top left image using GFS forecast for 15 Feb 2017. Top right image the Oroville Dam spillway failure on 13 Feb 2017 (Getty Images). Middle image showing ACAPEX and CalWater observations courtesy DOE. Bottom figure from Ralph et al., 2017

Abstracts are currently being solicited to cover topics including (but not limited to):

- Field observations and remote sensing of ARs
- AR identification and tracking
- Global and regional perspectives and impacts
- Physical processes and moisture transport in ARs
- Interactions between atmospheric transport and chemistry
- Current forecasting capabilities and opportunities
- Paleo—AR related floods and impacts
- ARs and climate change
- Emerging directions

International organizing committee

Michael DeFlorio (*NASA JPL; Co-Chair*)
Alexandre Ramos (*Instituto Dom Luiz, Portugal; Co-Chair*)
Michael Warner (*USACE Seattle; Co-Chair*)
Anna Wilson (*CW3E, Scripps; Co-Chair*)
Elizabeth Barnes (*Colorado State University*)
Rene Garreaud (*Universidad de Chile*)
Irina Gorodetskaya(*University of Aveiro, Portugal*)
David Lavers (*ECMWF*)
Ashley Payne (*University of Michigan*)
Chris Smallcomb (*NWS Reno*)
Harald Sodemann (*University of Bergen*)
Michael Wehner (*Lawrence Berkeley National Lab)*

The conference will be held at the beautiful oceanfront venue of the Robert Paine Scripps Forum for Science, Society and the Environment located at the Scripps Inst. of Oceanography, Univ. of CA – San Diego.

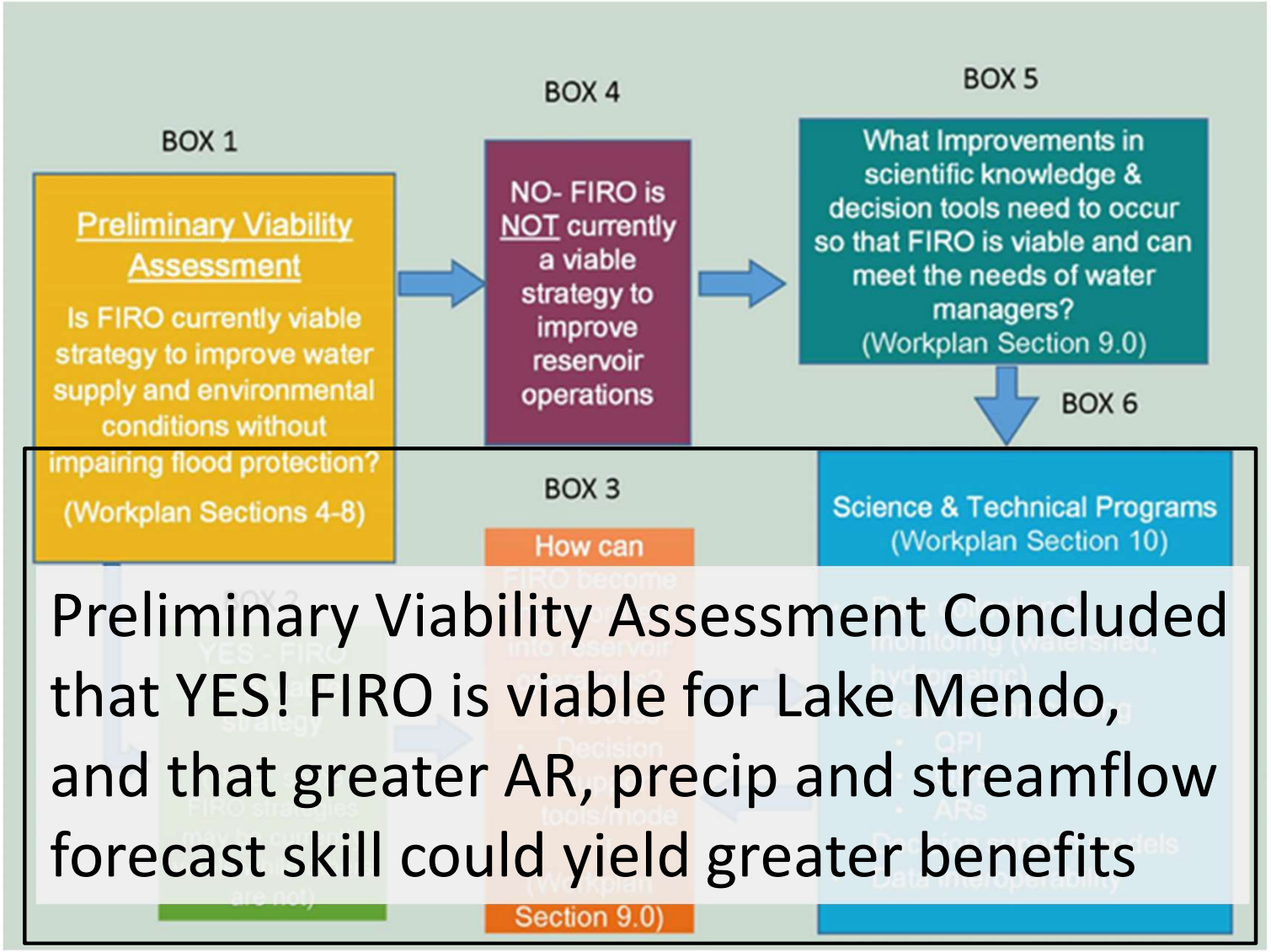
Contributions for the 2018 Conference are now invited

See the website to submit an abstract and register:
http://cw3e.ucsd.edu/IARC2018

Students are strongly encouraged to attend. Scholarships are available, as well as slots for student speakers.

For further information, please contact:
Anna Wilson anna-m-wilson@ucsd.edu or
Alexandre Ramos amramos@fc.ul.pt

FIRO Viability Assessment Process



Preliminary Viability Assessment Concluded that YES! FIRO is viable for Lake Mendo, and that greater AR, precip and streamflow forecast skill could yield greater benefits

Steering Committee report finalized July 2017